Emerging Ideas I

Ubiquitous Methane Sensing

Phil Larochelle,
ORISE Postdoctoral Researcher
Contractor to ARPA-E

Switching from Coal to Natural Gas Reduces CO_2 Emissions

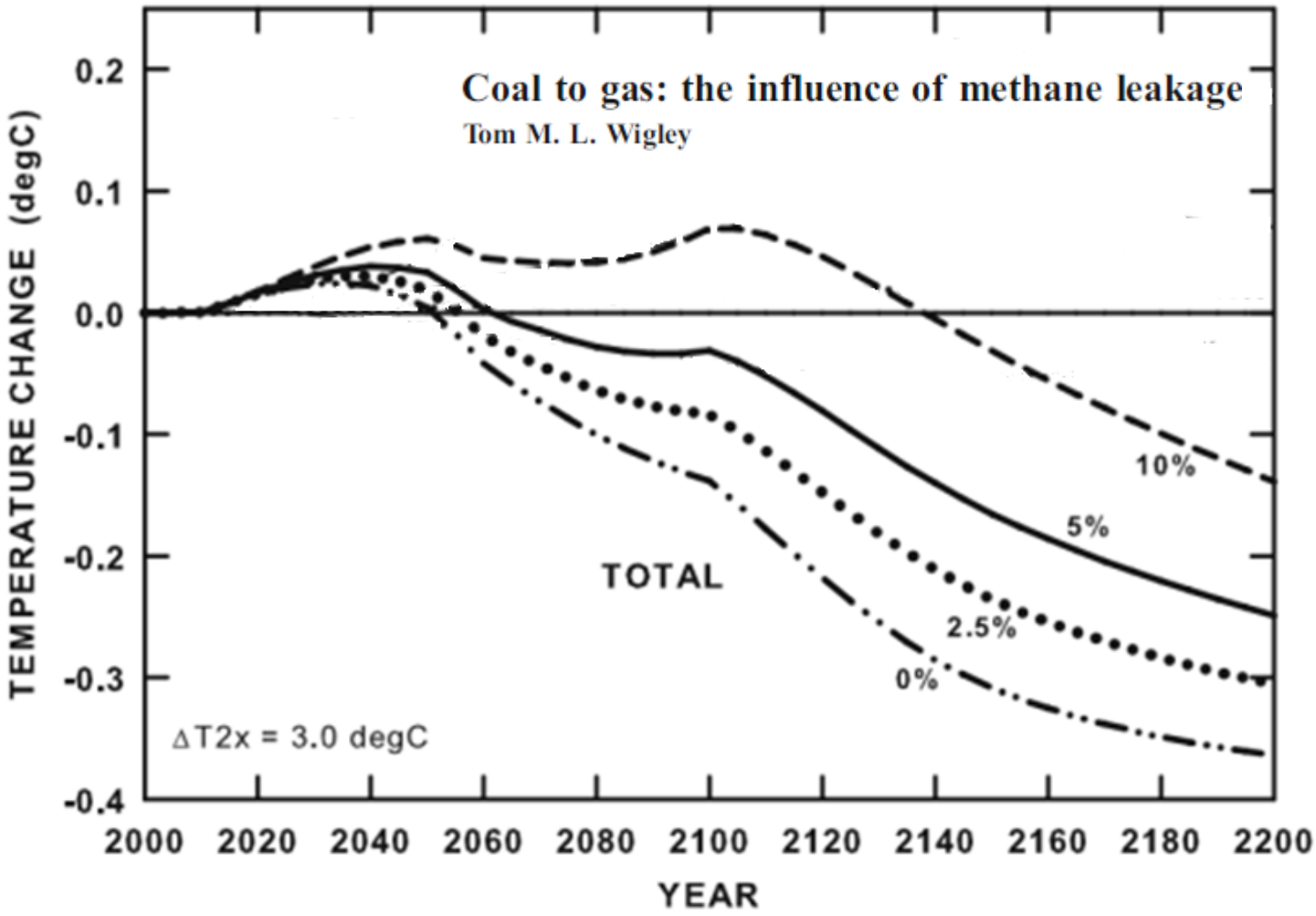
However, Methane is a powerful Greenhouse Gas

	Global Warming Potential		
Gas	**25 Years**	**100 Years**	**500 Years**
CO_2	1	1	1
CH_4	56	21	6.5

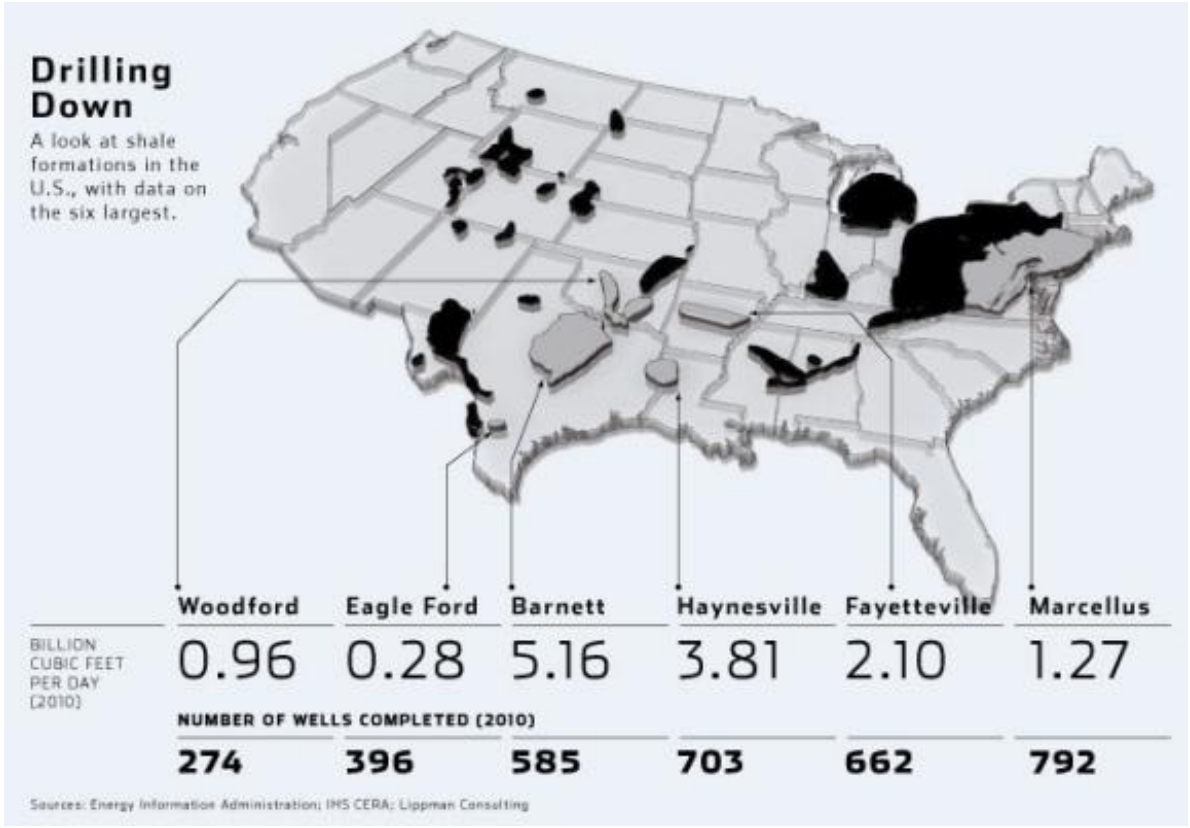
- Methane is a significantly more powerful GHG than CO_2
- It falls out of the atmosphere more rapidly than CO_2

- Methane leaks from Natural Gas Infrastructure can reduce or eliminate GHG benefit of switching from coal to natural gas

Methane Leaks Can Make GHG Emissions from Natural Gas Worse than Coal



> 3500 Shale Gas Wells Were Drilled in the US in 2010



Dan Yergin, Wall Street Journal

Is anyone checking all of these wells for methane leaks "Invisible Oil Spills?", can the Industry Self Regulate? This is also a wasted resource, and wasted $$.

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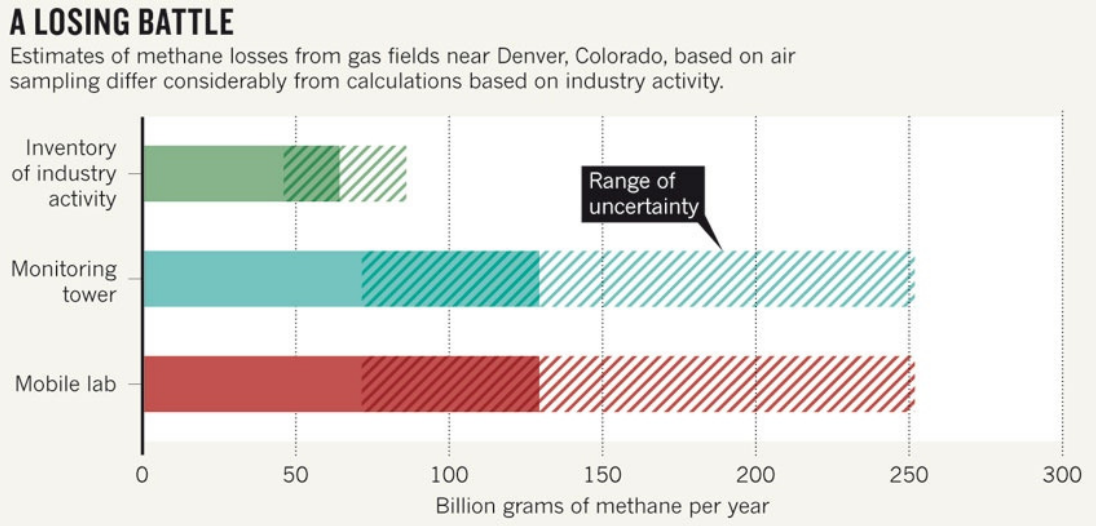
Report in Nature 2/12: Natural Gas Producers in Denver Area losing ~4% of their Methane.

nature International weekly journal of science



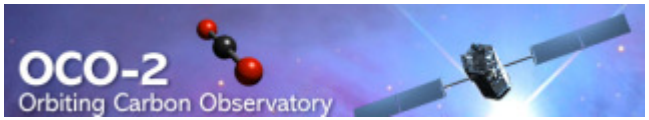
"the debate has been marked by a scarcity of hard data."

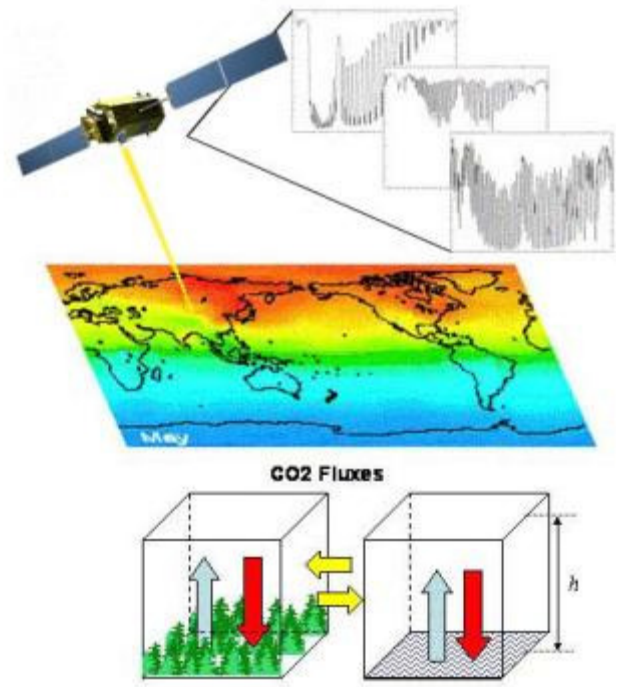
Techno-Economic Goal

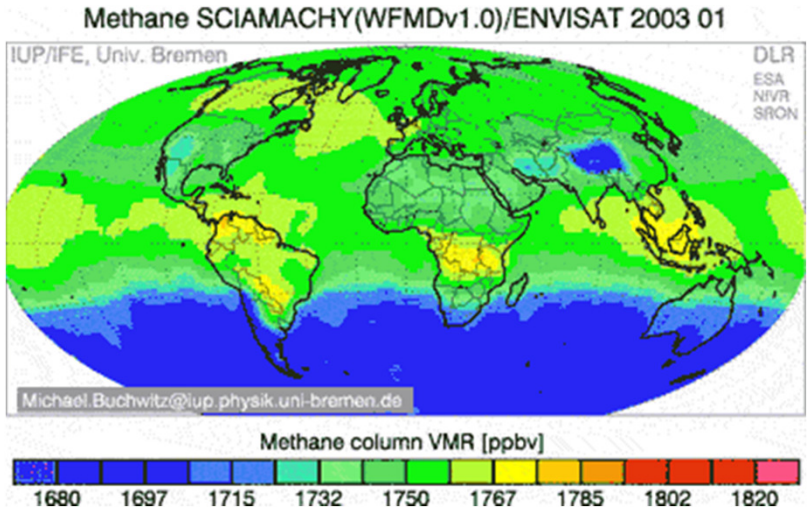
Find the Leaks and Stop Them.

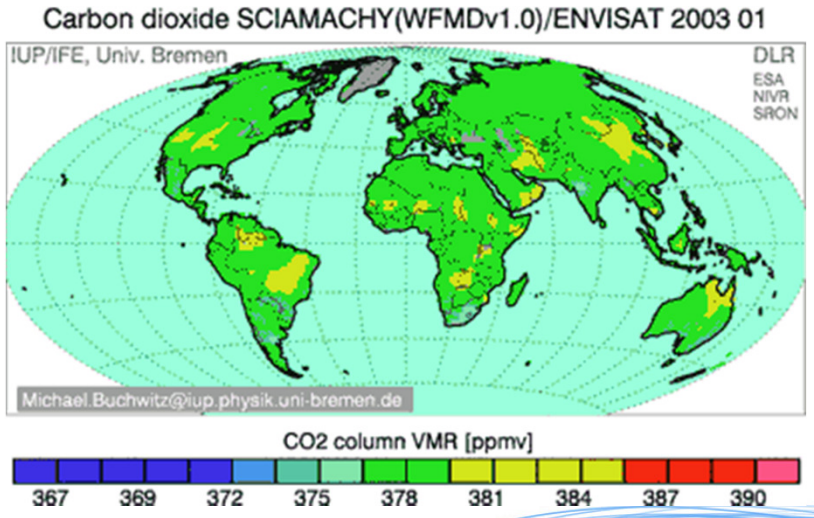
Precise Ubiquitous Geospatial Location
Of Methane Concentrations in the Atmosphere
1 square mile increments
1 PPM Resolution

There are satellite based CH4 & CO2 measurements, can we increase their resolution?



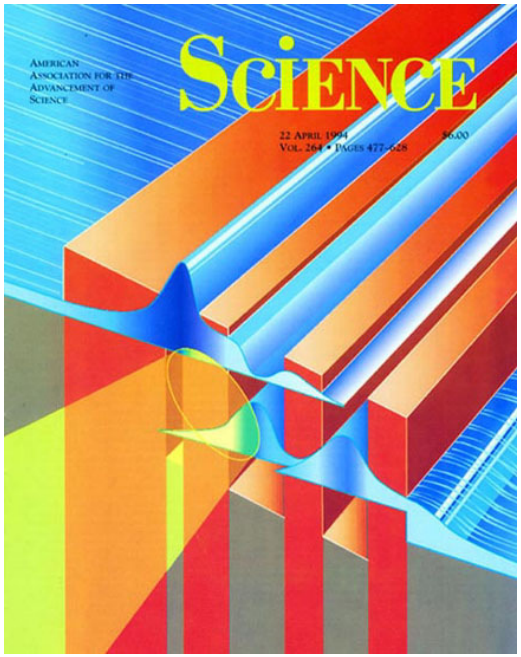


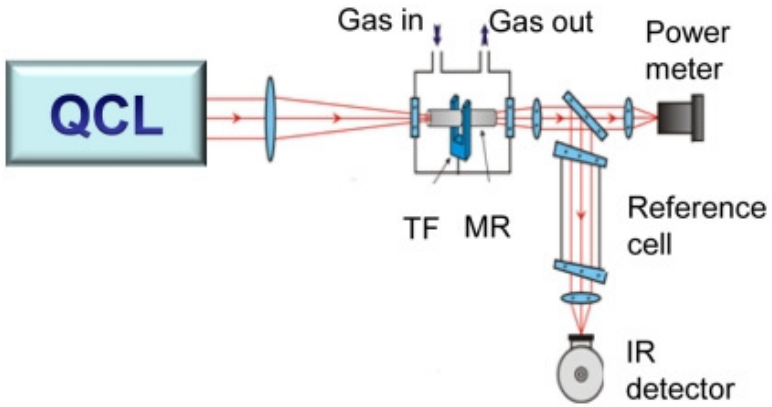




Remote Detection through Spectroscopy

Semiconductor Quantum Cascade Lasers Developed @ Bell Labs





Can the Detection Range be Extended?

Appl Phys B
DOI 10.1007/s00340-011-4800-0

Applied Physics B
Lasers and Optics

Quantum-cascade laser photoacoustic detection of methane emitted from natural gas powered engines

M.V. Rocha · M.S. Sthel · M.G. Silva · L.B. Paiva · F.W. Pinheiro · A. Miklòs · H. Vargas

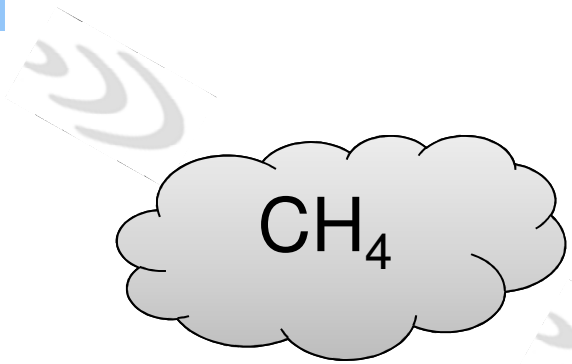
Received: 8 June 2011 / Revised version: 14 September 2011

Technology that can do it

Plane/UAV to Ground Spectroscopy (Triangulation)

CH_4

Technology that can do it

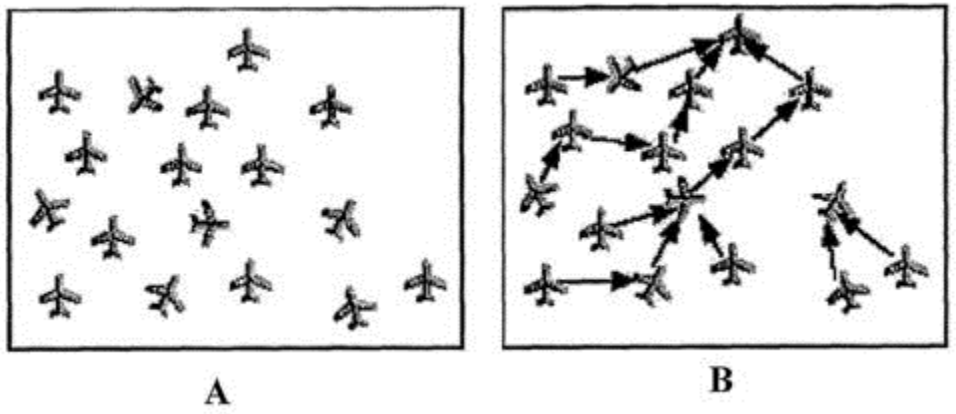


Plane/UAV to Plane/UAV
Spectroscopy
(Triangulation)

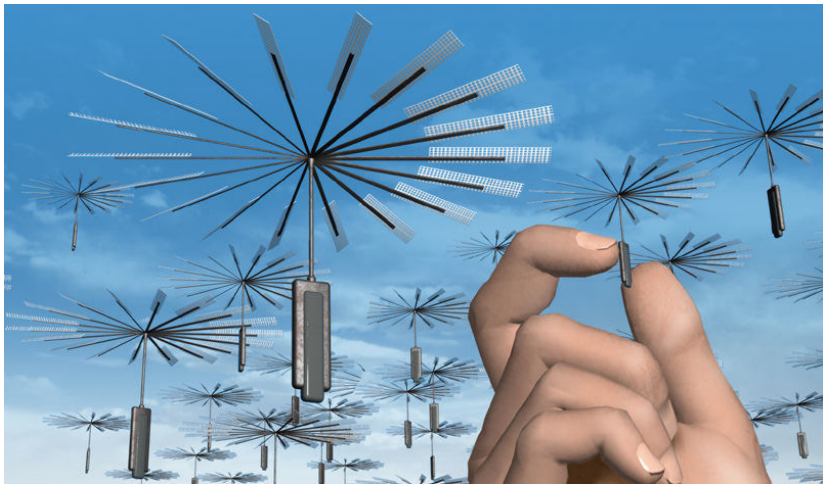
Smaller Types of UAVs: QuadRotors, Others

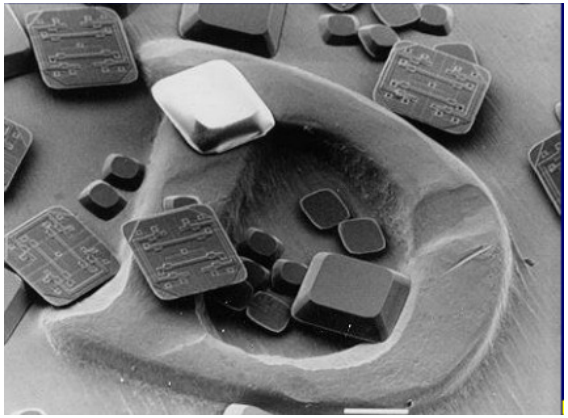
10 cm

Intelligent Coordination of many UAVs

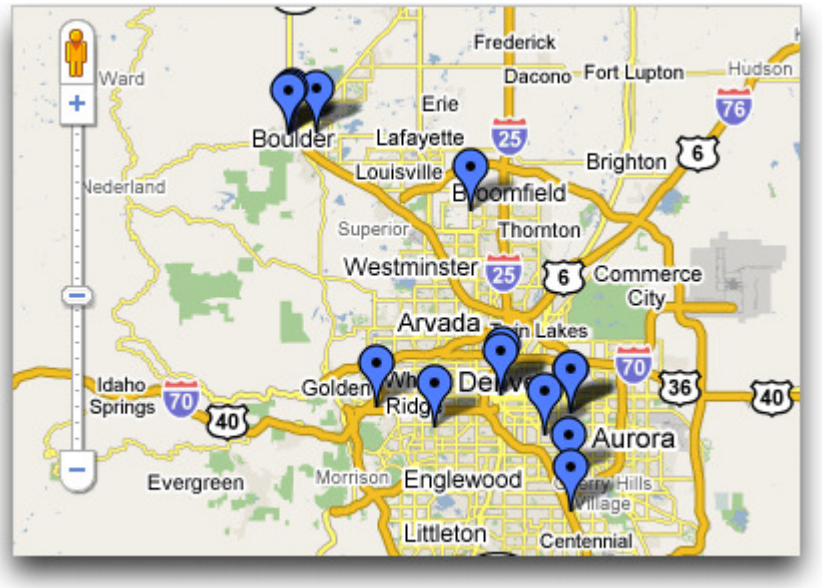


Going Even Smaller: Super Small UAVs and The Smart Dust Concept





Can We Crowdsource It?



Give people cheap sensors and Iphone/Android Apps.

Follow the Concentration Gradients

Methane Leak Detection Program Name:

S ENSORS &

N ETWORKS

I NTEGRATED

F OR

F INDING

E MISSIONS

R EMOTELY

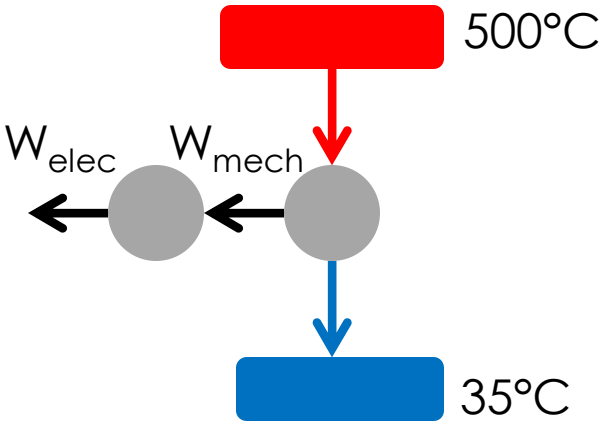
Emerging Ideas

Topping Cycles for Power Generation

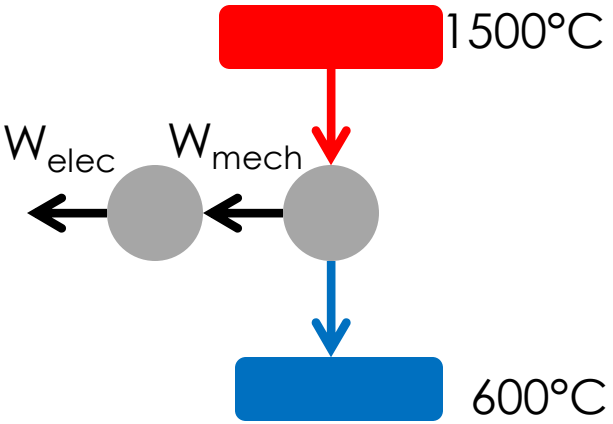
Asegun Henry, ARPA-E Fellow

Heat Engines

Steam-Rankine

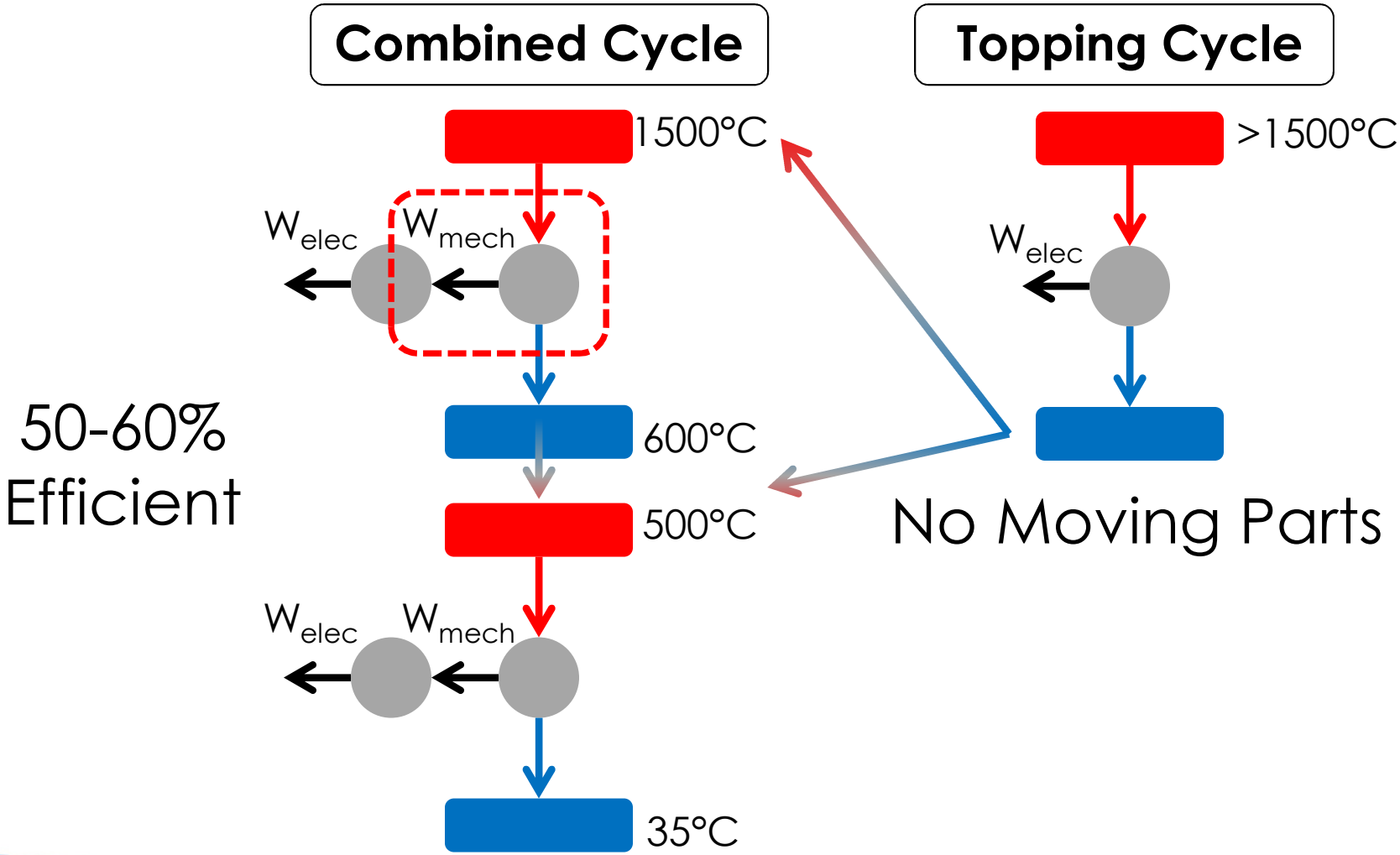


Air-Brayton



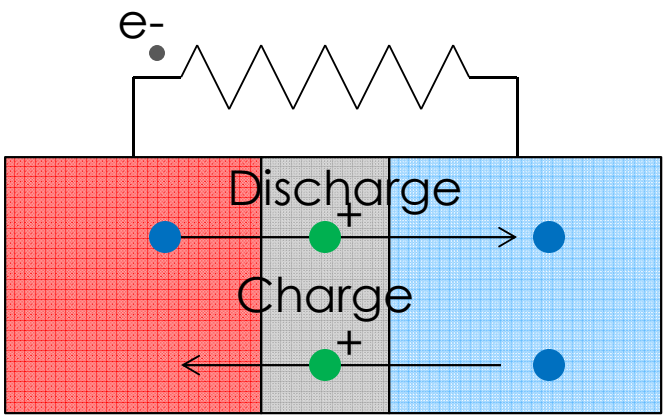
30-40% Efficient

Heat Engine Stack

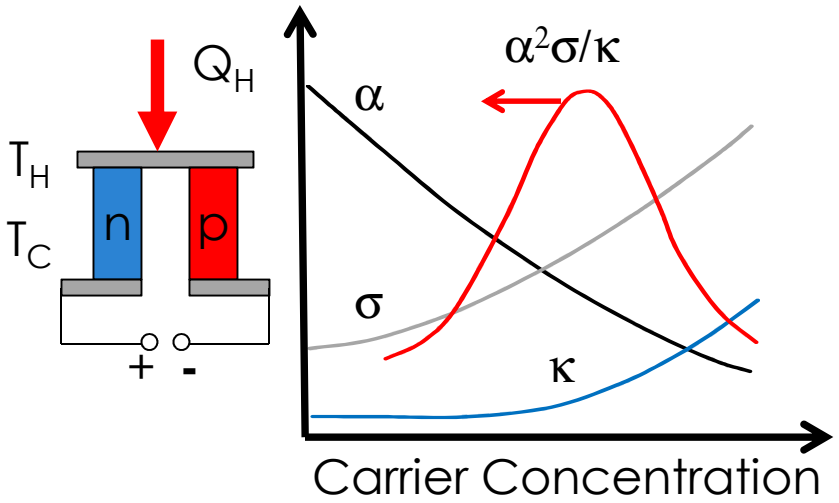


What Can Get Us There?

Thermally Regenerative Electrochemical Systems



Thermoelectrics



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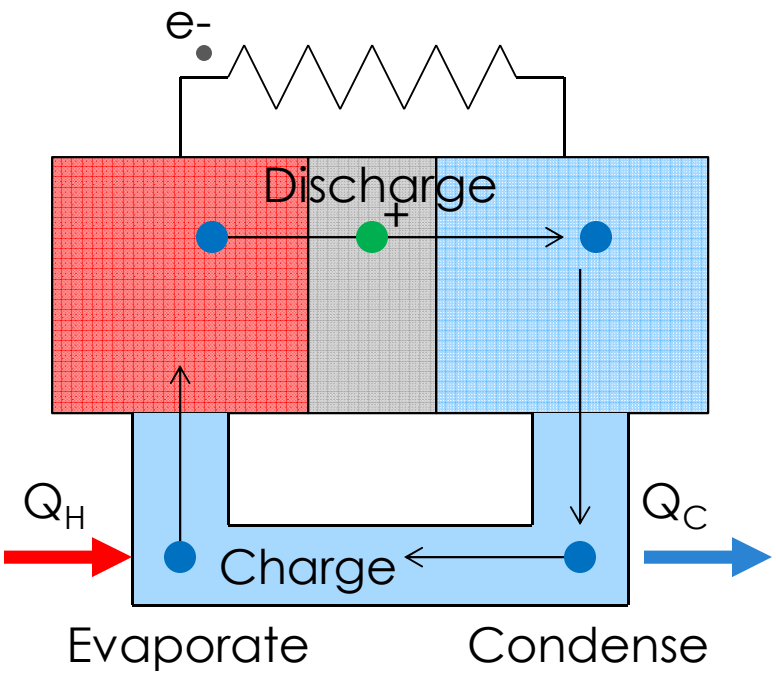
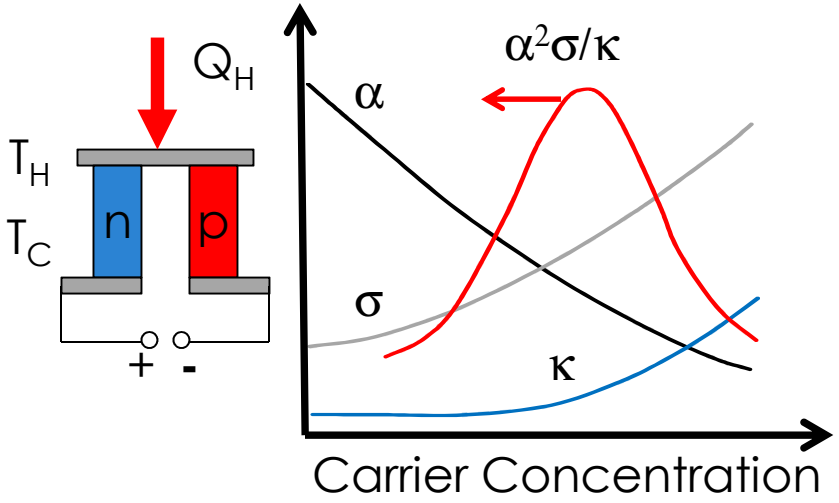
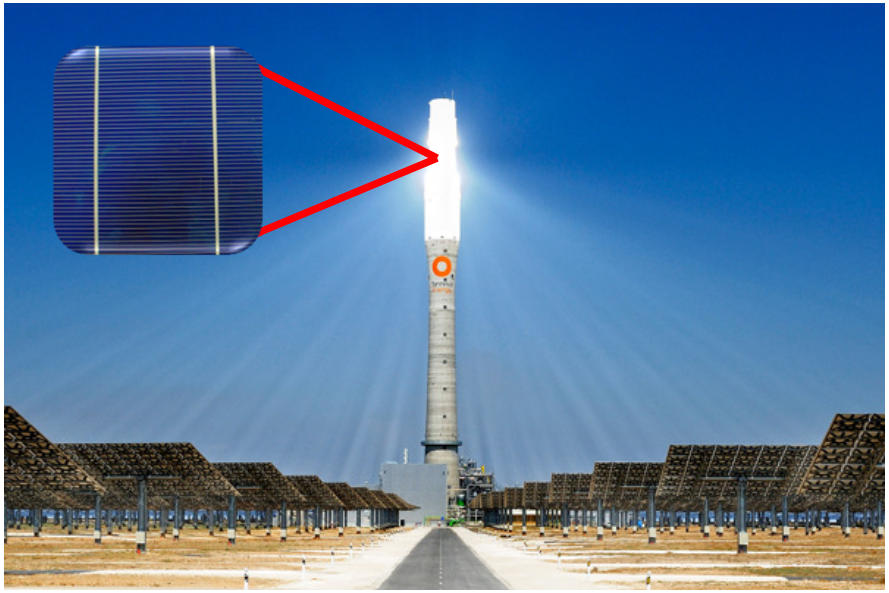


Thermoelectrics

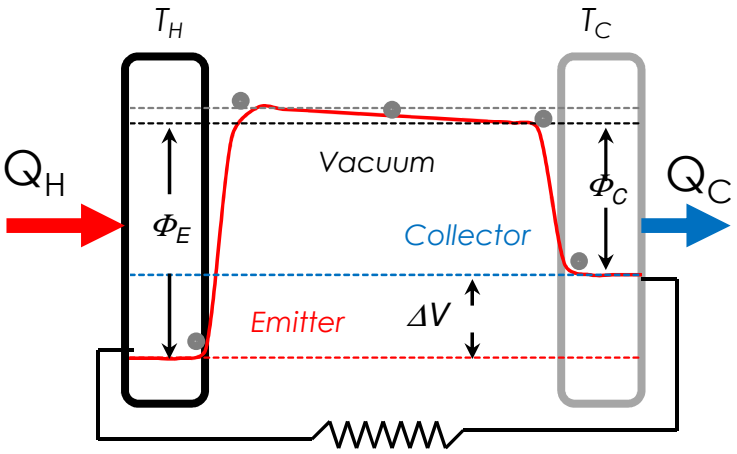


What Can Get Us There?

Photovoltaics at High Temperature (565°C)



Thermionic energy conversion



Goal: > 60% combined cycle, >10 yr lifetime

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Potential Program Name:

T HERMODYNAMICALLY

O PTIMAL

P OWER from the

H IGHEST

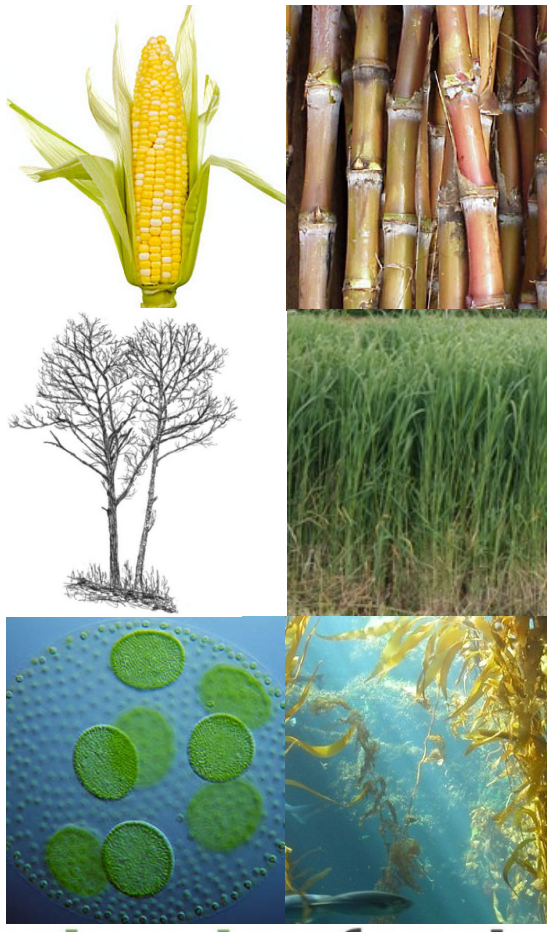
A CHIEVABLE

T EMPERATURES

Future Bioreactor Concepts

Robert Conrado
ARPA-E Fellow

All biofuels face similar challenges



electrofuels

Challenge

1) Footprint

2) Process efficiency

3) Land/water requirements

Direct conversion offers significant opportunity

Sunlight

Opportunity

Renewable Electricity

1) Small footprint

2) High efficiency

3) Low land/water use

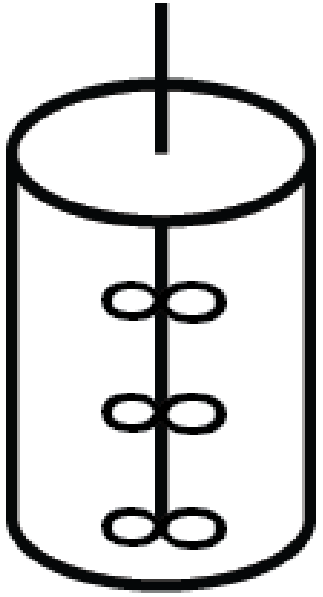
Fundamentally different challenge to convert sunlight/electricity vs. sugars into fuel

Sunlight

Renewable Electricity

VS.

Sugar-based Biofuels

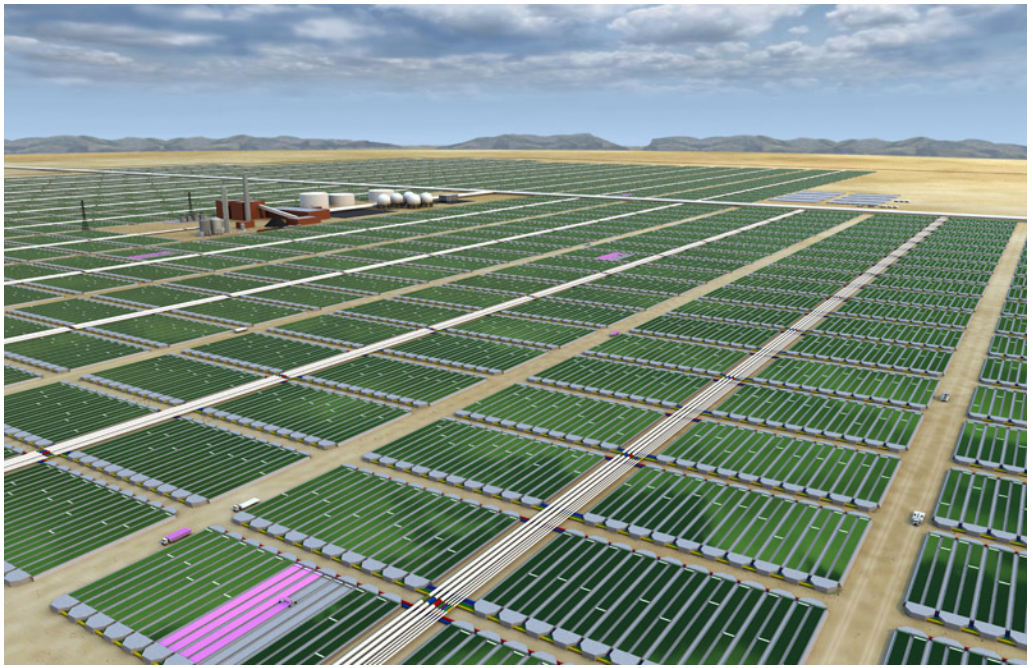


How is this done today? Why is it hard?

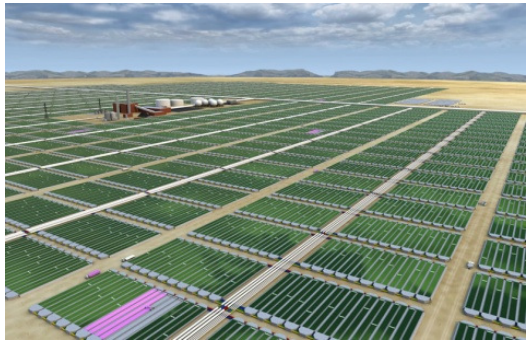
1) Large Bioreactor Areas

2) Long Time Scales

3) Energy Intensive

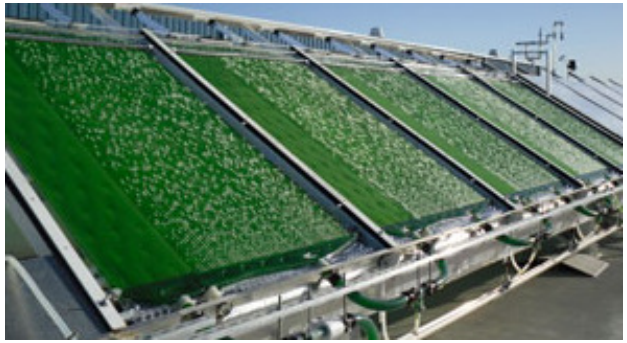


Few bioreactor designs being explored



Open Pond
0.5 m^2/m^3

Tube Photobioreactor
0.5-5 m^2/m^3

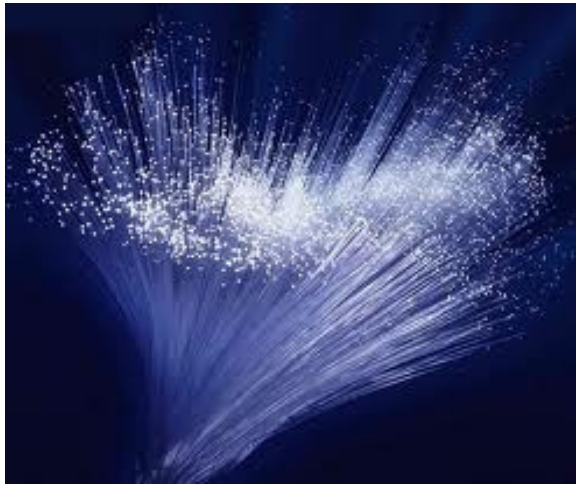


Sheet Photobioreactor
10-50 m^2/m^3

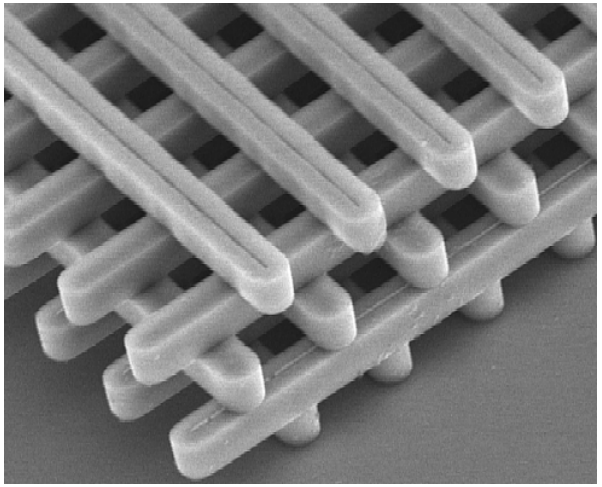
To achieve commercially relevant productivities, require
>500 m^2/m^3

Potential solutions from optics community

Photobioreactors concepts



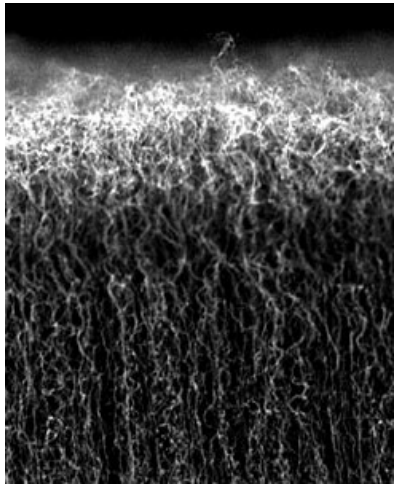
Optical Fibers
10^3-10^4 m^2/m^3



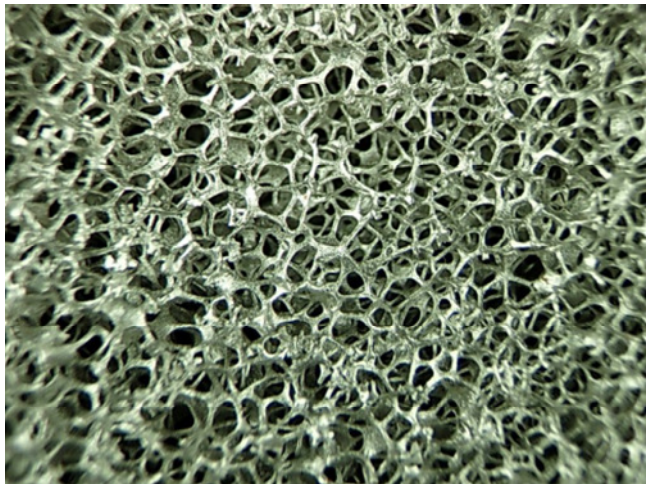
Photonic Crystal
10^5-10^6 m^2/m^3

Potential solutions from materials community

Electrobioreactors concepts



Battery Electrode
10^3-10^4 m^2/m^3



Nickel Foam
10^3-10^4 m^2/m^3

MICROBIAL

INTERFACES AND

COATINGS FOR

REACTOR

OPTIMIZATION IN

BIO

ENERGY

SYSTEMS

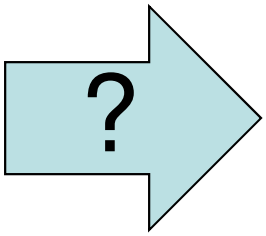
Rapid EV Charging

Amul D. Tevar, ARPA-E Fellow

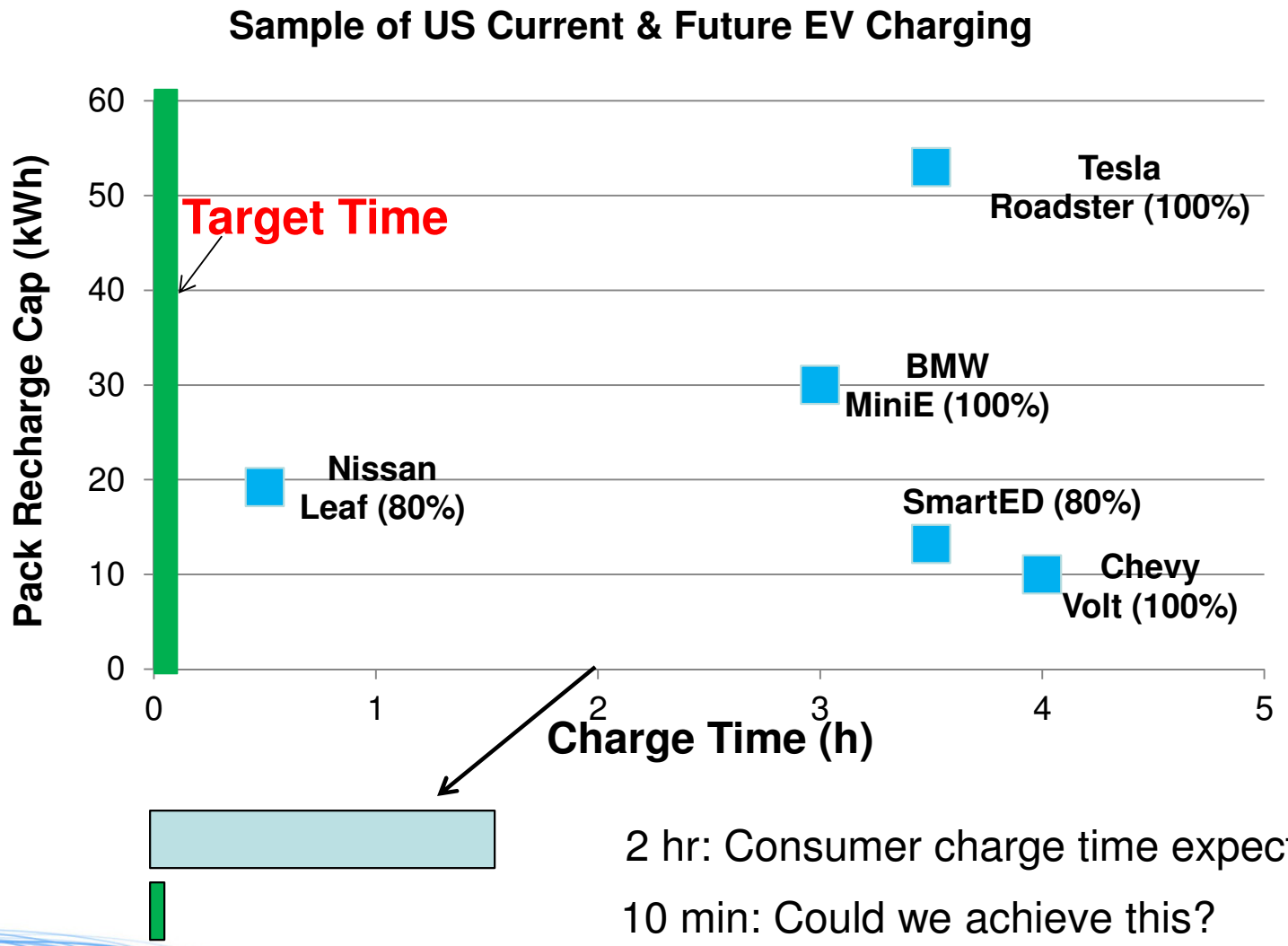
Could EV charging be made more convenient than filling a tank of gas?

'I sure don't want to sit around twiddling my thumbs for 30 minutes at a "charge station" waiting for an EV to charge…'

- Comment from hybridcars.com forum



Most Li-Ion pack charging times are long

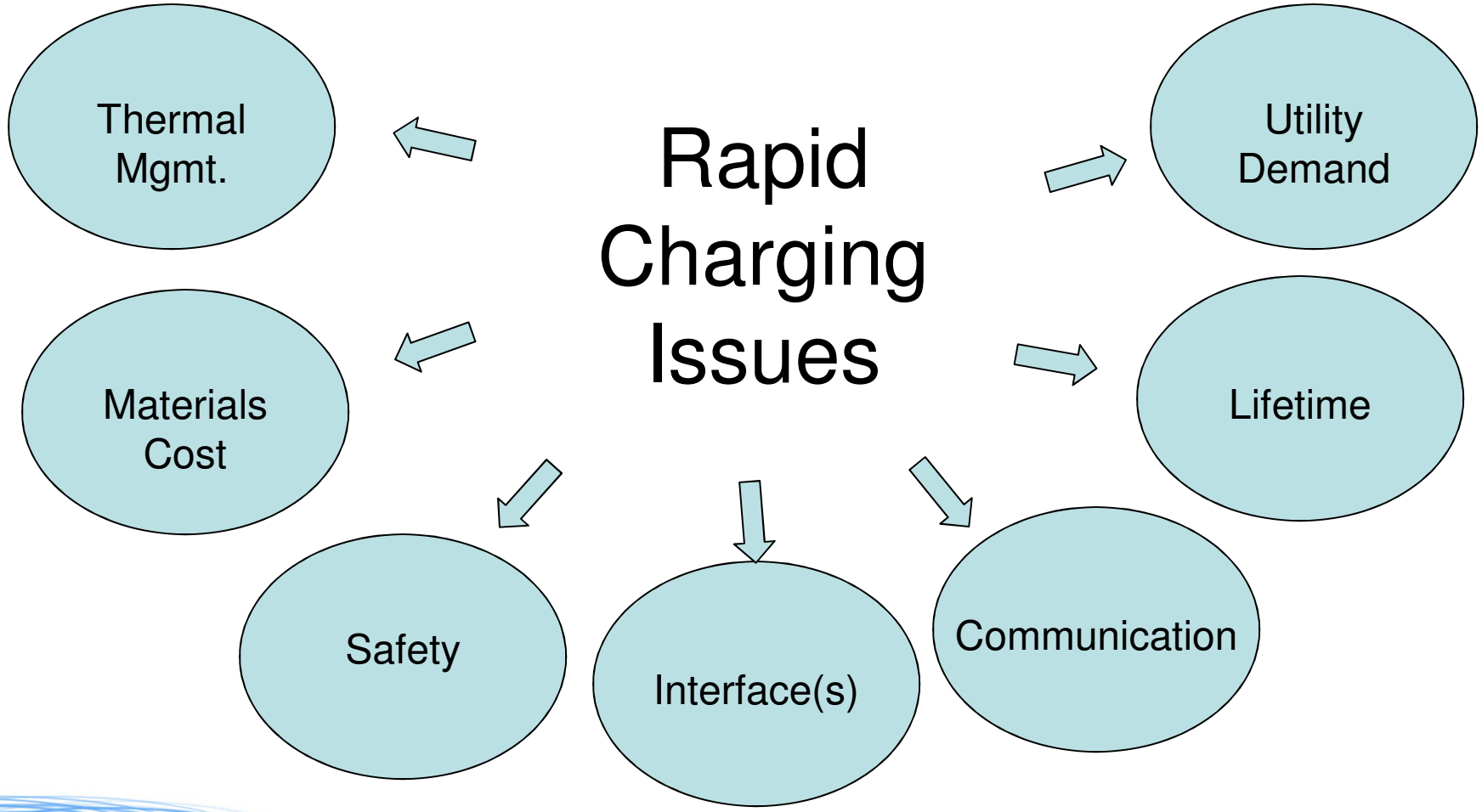


2 hr: Consumer charge time expectations

10 min: Could we achieve this?

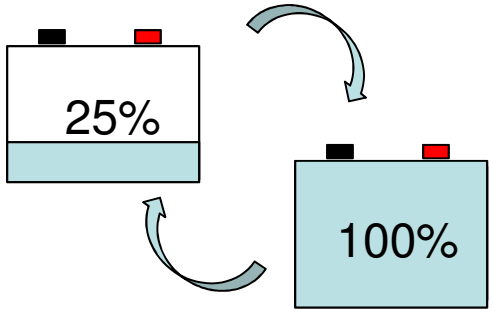
Sources: Manufacturer Spec Sheets
Deloitte Survey, Unplugged: Electric Vehicle Realities

Significant technical issues with rapid charging

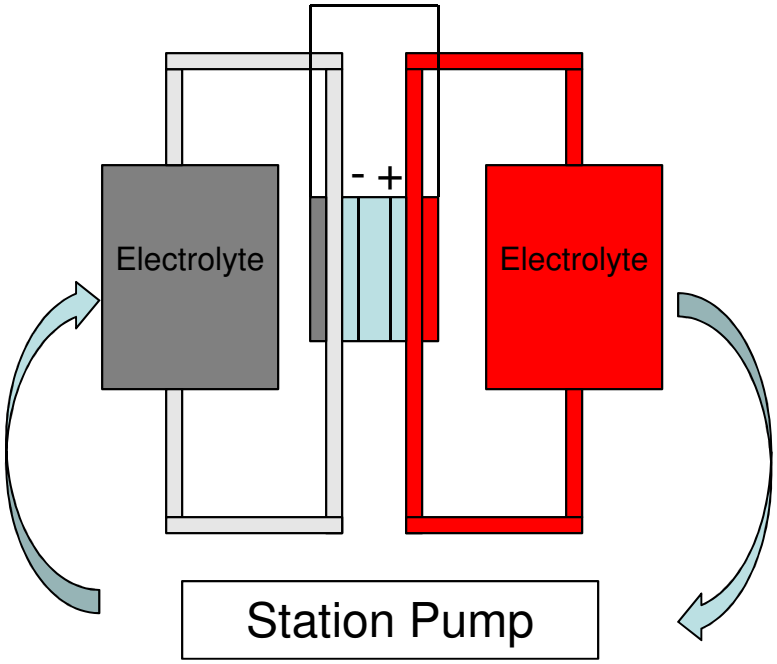


How could we approach this?

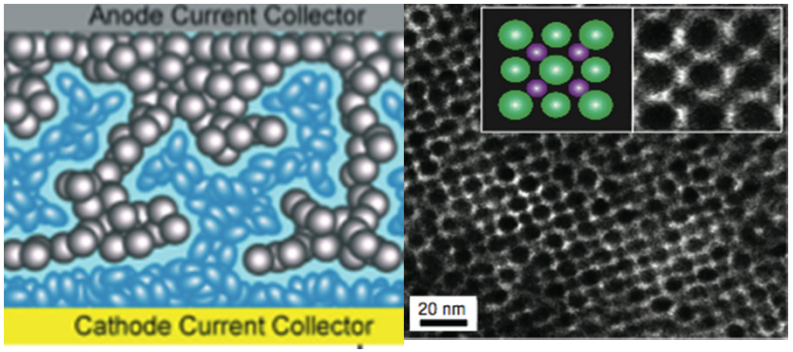
Battery Swapping. . . but why swap the whole thing?



EV Flow battery



EV Self-assembled battery



Just pump fluid at station and recharge without removing battery

Sources: Adv. Funct. Mater. 2007, 17, 379–389
Nature Matls, vol. 6, 2007,

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What else with rapid charging?

Rapid Charge Stations

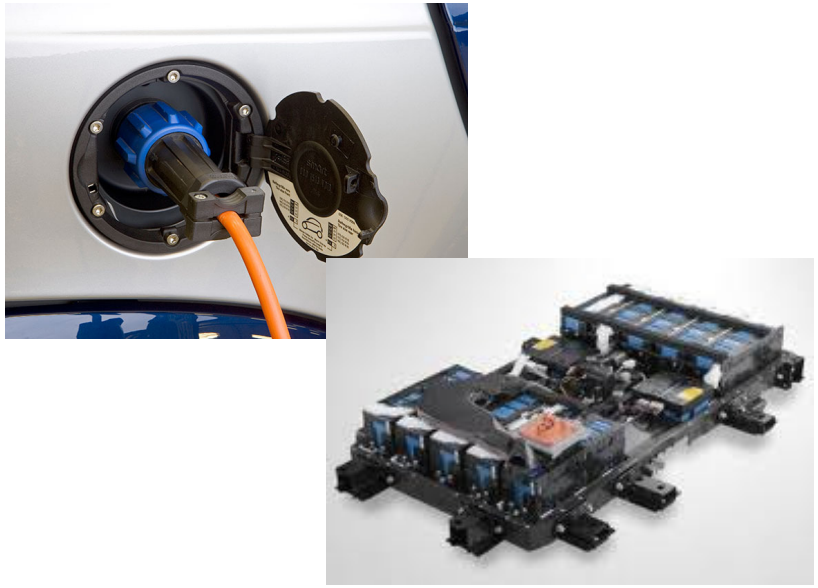
Removes cost of at-home charging units

Inductive/Wireless Charging

Charging without cables

Source: Botsford, C. & Szczepanek, A. *Intl Batt, Hybrid and Fuel Cell EV Symposium, 2009.*

What would the solution look like?



- Key: Driving Miles per Minute Charge
- Safety & Stability

- How can we avoid traditional battery issues or limitations?
- Are there advances from other fields?
- Are there secondary issues that may make high rates intractable?

Image: Wired.com

Potential Project

RAPID

ACTIVE

CHARGING

ENVIRONMENT